U.S. Department of Agriculture Agricultural Research Service
May 1982

Agricultural Research

How Much Is Soil Worth?

Finding an answer to the question "How much is soil worth?" may be complex and challenging, but that's the kind of question economists and scientists engaged in soil and water conservation research are ready to tackle. Remember, the tradition of soil and water researchers includes development of the Universal Soil Loss Equation (USLE), which helps conservationists assess erosion hazards under a variety of conditions.

More recently these scientists developed the Agricultural Chemical Transport Model (ACTMO) and the field-scale model for Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) to meet the challenge of assessing the hazards of water pollution.

The present challenge is to respond to Public Law 95-192, the Soil and Water Resources Conservation Act of 1977 (RCA). In this law the Secretary of Agriculture is charged with making an appraisal of soil, water, and related resources and their conservation and with making informed, long-range policy decisions regarding the use and protection of these resources.

Until the relationship between erosion and soil productivity is well defined, however, selecting management strategies to maximize long-term crop production is well nigh impossible. Can-do attitudes of scientific teams tackling this great issue of our time are necessary if we, as a Nation, are to maintain our economic strength through exports. We simply must not continue to export our soil with our grain through erosion.

The problem, of course, is scientific, socioeconomic, and political. One of the most dangerous aspects of this problem is that it may be insidious. Erosion reduces productivity so slowly that it may not be taken into much account until the land is no longer suitable for growing crops. Furthermore, capital inputs from our technological society may mask the reduction in productivity. For example, some eroded soils respond well to heavy fertilizer applications. But then, consider what happens when the price of energy needed to produce fertilizer skyrockets.

Because the problem is multifaceted, the solution will be multidisciplinary. The Agricultural Research Service's commitment to the solution is exemplified by a workshop held in September 1981 that involved scores of professionals—scientists, agricultural engineers, soil conservationists, economists, and administrators.

From the scientific perspective, most of the research that has been conducted to date has been on individual processes involved in the soil erosion/soil productivity problem. Now, computer models are being developed to link the components of our knowledge on hydrology, erosion and sedimentation, livestock grazing, nutrient cycling, crop growth, tillage, soil properties, climate, pesticides, insects, diseases, and economics.

To describe the systematic integration of knowledge for farm use, scientists are now frequently using the term "conservation production systems." The idea is to avoid waste of the soil while maintaining a high level of crop production to support our export economy.

Conservation tillage practices increasingly may lie at the heart of conservation production systems in many farming areas. Adoption of these practices by more and more farmers may depend on the integration of knowledge from detailed studies and the development of models that apply to a variety of situations.

From a policy standpoint, should research emphasis and conservation incentives be applied uniformly across our Nation, or should the attention be directed to areas where the erosion problem is most serious? We hope that our available knowledge and the results of research that is underway will help decisionmakers arrive at informed judgments.

Ben Hardin, Peoria, Ill.

Contents

Agricultural Research
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Cover: Putting just enough water just where it's needed—using less energy—is the goal of ARS irrigation research. At the Snake River Conservation Research Center, Kimberly, Idaho, improved furrow irrigation techniques on semiarid land can reduce water use by one-half. Here the test crop is beans. (Article on page 8.) (0874X1357-15)

Helping Plants Defend Themselves

Heliothis zea feeds on a soybean pod. This voracious insect is commonly known as the corn earthworm, the bollworm, the podworm, or the tomato fruitworm, depending on the crop under attack. (1176X1500-19)

Chemical control of insects that attack crops in the United States requires more than 650 million pounds of pesticides each year at a cost of more than $2 billion. Even so, it is estimated that 13 percent of these crops are lost annually to insect damage.

The use of insecticides cannot be eliminated without seriously curtailing agricultural production. "However, insecticides can't be expected to do a complete job," says ARS chemist Anthony C. Waiss, Jr. "Insects often rapidly develop resistance to chemicals before suitable replacements can be found. In addition, insecticides often inadvertently kill beneficial insects and other wildlife and can pose serious health hazards to humans if not handled properly."

Integrated pest management (IPM) coordinates the use of insecticides, other chemicals, biocontrol measures, cropping practices, and plant varieties that are insect resistant. Now scientists have incorporated into IPM, selective plant breeding—an accelerated version of evolution—to furnish growers with more resistant crops.

Nature and man both practiced plant selection long before recorded history. Plants that survived insect attack produced seed for the next crop. Only recently have scientists begun to speed up this natural process.

If scientists discover more of the basic mechanisms that make some plants more insect resistant than others, it would improve the efficiency of genetic manipulation in developing more resistant crops. Waiss and his research group at the Western Regional Research Center, Berkeley, Calif., with the cooperation of many ARS scientists, have identified resistance factors in several major crops.

The researchers investigated the chemical constituents of four economically important plants—cotton, corn, soybean, and sunflower—and found that some plant chemicals were responsible for reducing insect damage by inhibiting insect growth. To identify these chemicals, sometimes concentrated in specific plant parts, they first had to use elaborate, time-consuming tissue dissection and sequential solvent extraction techniques to obtain material for bioassay.

Waiss and his group developed novel microassay procedures to locate active chemicals and to verify and evaluate their effectiveness against specific insects.

Cotton. For many years, natural resistance of cotton to several insects has been ascribed to the presence of gossypol in discrete glands of the plant. Many breeding efforts, therefore, have been directed toward increasing the gossypol content.

However, two recent findings have cast doubt on this practice. First, some "glandless" lines showed resistance to cotton pests, and second, it was found that gossypol was not the major factor in the resistance of certain lines to bollworms and spider mites.

ARS scientists have shown that natural resistance of cotton is very complex. In addition to gossypol and other related terpenoids, condensed tannins, certain cyclopropenoid acids, and certain monomeric flavonoids also provide antibiotic resistance to such cotton pests as tobacco budworm *(Heliothis virescens),* bollworm *(H. zea),* and pink bollworm *(Pectinophora gossypiella).*

A critical resistance element is the concentration of these chemicals in the specific plant organs attacked by larvae. For example, young tobacco budworm larvae feed on growing plant tips and anthers of young flower buds, and later continue feeding on other floral parts.

Isolation and identification of the most active components of cotton squares showed that condensed tannin most effectively provided resistance. Upon careful dissection of the flower bud parts, the scientists found that tannin content of anthers was much lower than that of other floral organs. When larvae were fed various parts of the bud, their growth was inhibited in direct correlation to tannin content, but there was no correlation with the gossypol content. Larvae tested after initial feeding on a standard diet showed that tolerance for condensed tannin increased as the larvae aged. Therefore, the chemicals present in the initial feeding site would be greater determinants for resistance.

Two cyclopropenoid acids were found in flower bud tissue. Although the amount present in floral tissue is not great enough to limit larval growth markedly, the concentration is greater in developing seeds, where the cyclopropenoid acids may exert an important protective role.

The monomeric flavonoids known to be present in cotton have significantly different effective levels against the different species of cotton pests.

"The natural resistance of cotton is, thus, due to combinations of several allelochemics and the levels of occurrence of these in the particular plant portion upon which the insects feed," says Waiss. "This information should assist researchers in choosing, early in their breeding programs, plant varieties best equipped to resist insect damage."

Corn. A principal pest of sweet corn is *Heliothis zea,* commonly called the corn earworm when it attacks this crop. Young larvae first develop on corn silk, then move down the ear and feed on the kernels, causing unsightly and economically important damage.

Previous research indicated that silk from some corn lines was "lethal" to young larvae, but the active factor was not identified. The scientists analyzed corn silk from these resistant lines and discovered that a flavone glycoside (maysin) was effective in controlling corn earworm larvae. When they fed young larvae fresh corn silk, their growth was reduced in direct correlation with the maysin content of the silk.

Silk from resistant corn lines contains more maysin than silk from susceptible lines. Field corn generally contains more maysin than sweet corn. However, the scientists have discovered some sweet corn lines that contain significant maysin levels. Sweet corn with silk containing high maysin levels is now being genetically selected in several breeding programs to increase insect resistance.

Soybean. The larvae of podworm *(Heliothis zea)* feed on the soybean leaves and seed pods and may cause substantial damage. Certain cultivars are relatively resistant to attack, and when ARS scientists examined these lines, they found that nonpolar extracts were inactive against the podworm, but polar extracts severely retarded larval growth. The scientists identified pinitol as one of the active compounds in the polar extracts. Enough pinitol is in soybean leaves to significantly inhibit growth of feeding larvae.

Chemist Anthony Waiss, Jr. (left) and laboratory technician James Baker weigh insects to determine how effectively some chemicals retard insect growth. (0677X696-2)

Sunflower. The sunflower moth (*Homoeosoma electellum*) lays eggs on the flower head, and young larvae begin feeding on developing florets. They continue their damage by feeding on developing seeds.

Although prior observation had indicated that resistance might be due to a hard seed coat, two isomeric diterpenoid acids in the florets were shown to inhibit growth and development of sunflower moth larvae.

Both resistant and susceptible lines contain these diterpenoids in young florets. However, resistant lines contain toxic levels, whereas susceptible lines contain low levels. Significant levels of these chemicals at the initial feeding site of young larvae provide greatest resistance.

"These results show the promise of this research approach in developing insect resistance in major crop plants and should greatly speed genetic selection for resistance," says Waiss.

Anthony C. Waiss, Jr., is located at the Western Regional Research Center, 800 Buchanan St., Berkeley, CA 94710.—(By Dennis Senft, Oakland, Calif.) ■

No Sporting Chance for Small-Farm Weeds

At first glance, a newly created, handheld herbicide applicator looks like a prop from a science fiction movie—a jet-powered hockey stick with "fuel tank" and modified blade, ready for battle in tomorrow's sports arena.

But only weeds need fear this hockey stick-turned-herbicide wiper, according to William V. Welker, head of the weed science program at the Appalachian Fruit Research Station, Kearneysville, W. Va. The "fuel tank" holds an all-purpose herbicide, which is drawn downward by gravity through plastic tubing to the stick's sponge-covered blade, which is then wiped over the leaves of weeds. The wiper is part of a growing arsenal of application techniques bringing full-season weed control to the Nation's 1.3 million small, family farms.

Making sure that weeds receive no sporting chance on small farms has meant developing inexpensive, specialized application techniques, such as the hockey stick/herbicide wiper. The device can be made at home for as little as $15. It is part of a larger ARS effort to solve the problems of small-farm operators.

"Given the great diversity of conditions and farming philosophies, no single means of curbing weeds is suitable for all small farms," said Welker. "In most cases, however, integrated weed control techniques using herbicides, mulches, mechanical cultivation, and some biological controls are now available."

With full-season protection now a reality, small-farm operators and extension agents can identify weeds present in a field and tailor a weed management and crop rotation system that will provide both short- and long-term control.

In the past, small-scale agriculture's relatively complex multicropping practices had prevented the direct transfer of some weed management know-how from the large farm to the small.

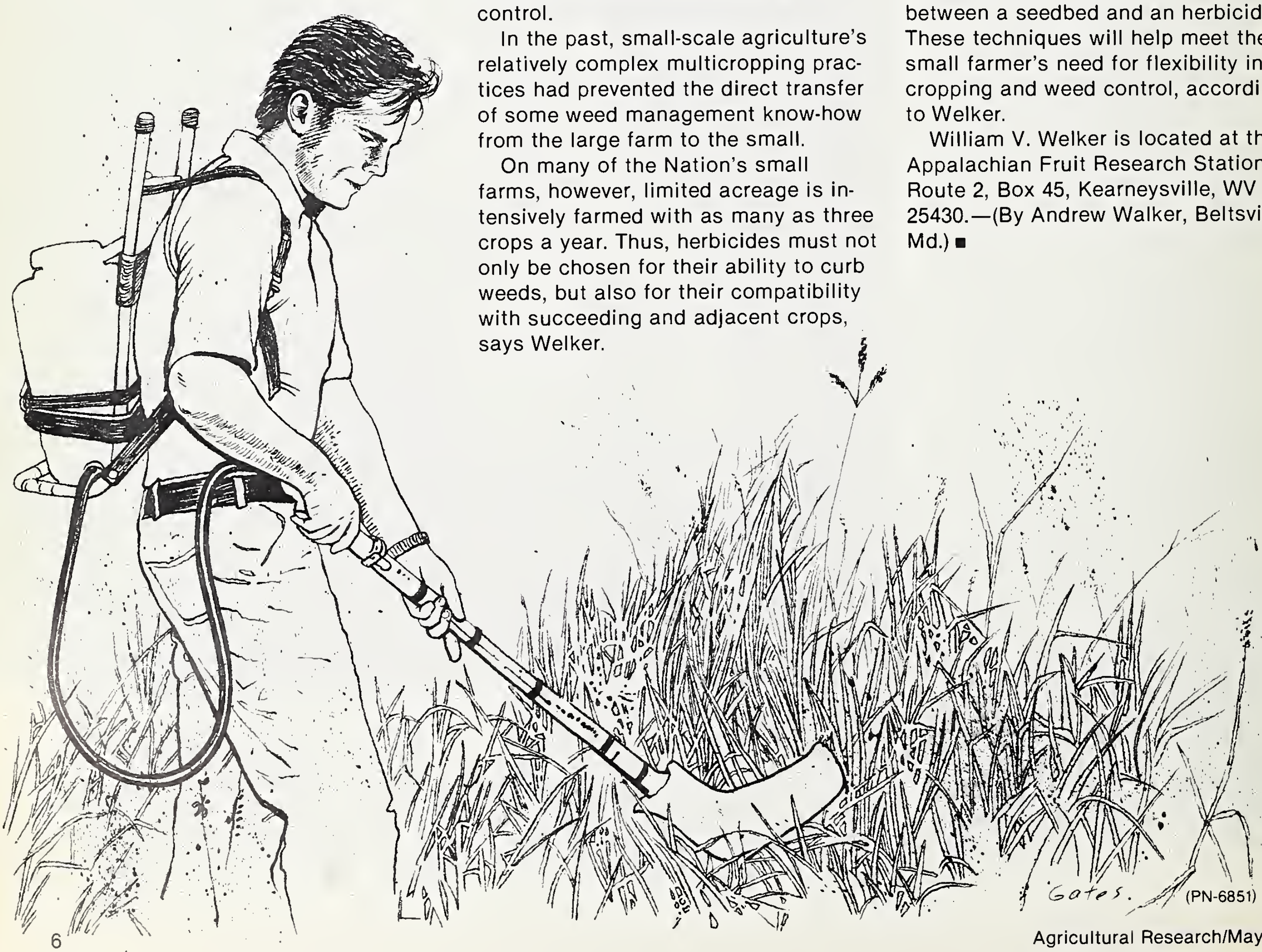
On many of the Nation's small farms, however, limited acreage is intensively farmed with as many as three crops a year. Thus, herbicides must not only be chosen for their ability to curb weeds, but also for their compatibility with succeeding and adjacent crops, says Welker.

In these and other situations, operators of small farms can often achieve their best results by using herbicides in conjunction with mulches, mechanical cultivation, and biological controls.

In fruit orchards, timely cultivation between trees will keep perennial weeds from getting established. Plastic, straw, or other mulches not only curb unwanted plants, but also provide favorable soil moisture, temperature, and aeration, often leading to increased yields and early ripening in many horticultural crops. Biological controls have the potential to curb problem weeds in perennial horticulture crops and to reduce pressure from a specific weed surrounding cropping fields.

Other ARS advances include a small-scale, over-the-row applicator and other devices that lift and spray underneath crops, reduce spray drift, and place a protective layer of activated charcoal between a seedbed and an herbicide. These techniques will help meet the small farmer's need for flexibility in cropping and weed control, according to Welker.

William V. Welker is located at the Appalachian Fruit Research Station, Route 2, Box 45, Kearneysville, WV 25430.—(By Andrew Walker, Beltsville, Md.) ■



(PN-6851)

"Greenhouse Effect" a Nonproblem?

Physicist Sherwood Idso checks solarimeter measuring incoming solar radiation. The steel band blocks direct sunlight and the meter records only scattered radiation. (1181X1409-28)

World climatologists predict that the rise in atmospheric carbon dioxide (CO_2) concentration from burning fossil fuels will raise surface air temperatures 2° to 4°C. This increase, they say, will change the world's weather, melt polar ice caps, flood coastal cities, and generally raise havoc with agriculture.

Sherwood B. Idso, ARS physicist and meteorologist, Phoenix, Ariz., disagrees. Idso says temperatures will not increase nearly that much and that burning fossil fuels will cause no climatic problem.

He suggests that either the climatologists are wrong or they have left something out of their predictive models.

Idso draws his conclusions from "real world" research at Phoenix, where for the past 12 years he has measured incoming solar and thermal radiation using variations in dust and water vapor as substitutes for the projected CO_2 increase. He has concluded that doubling atmospheric CO_2 will change surface air temperature less than natural climatic variability.

He says, "There is essentially no danger of significant climatic warming due to any forthcoming increase in atmospheric CO_2 concentration, even for a tenfold increase. Hence, not only is an increase in CO_2 not detrimental, it is desirable, for a doubling or tripling of the atmospheric CO_2 content could increase global agricultural productivity by fully 20 to 50 percent."

Plants use CO_2 for growth and fruiting. Scientists all over the world have more than doubled yields of many different crops in greenhouses by doubling CO_2 and increasing nutrients.

"Thus," Idso adds, "faced as we are with a still-expanding world population, we are probably going to need this added productivity edge. In fact, if one believes the 'population bomb' alarmists, more atmospheric CO_2 looms as an almost vital necessity."

Two major questions need answering in order to come up with conclusions on the atmospheric effects of burning fossil fuels. The first is "What will be the net increase in CO_2?" The second is "How does one calculate the temperature response of the near-surface air to the net increase in radiation?"

Idso and the climatologists agree on the first question. It is on the second that they disagree, and where Idso thinks something may be missing from the modelers' programs.

He has calculated the projected increase in temperature by three different, independent methods. All three are based on real world data, and all produced the same answer: Doubling atmospheric CO_2 will increase the temperature about 1/4°C.

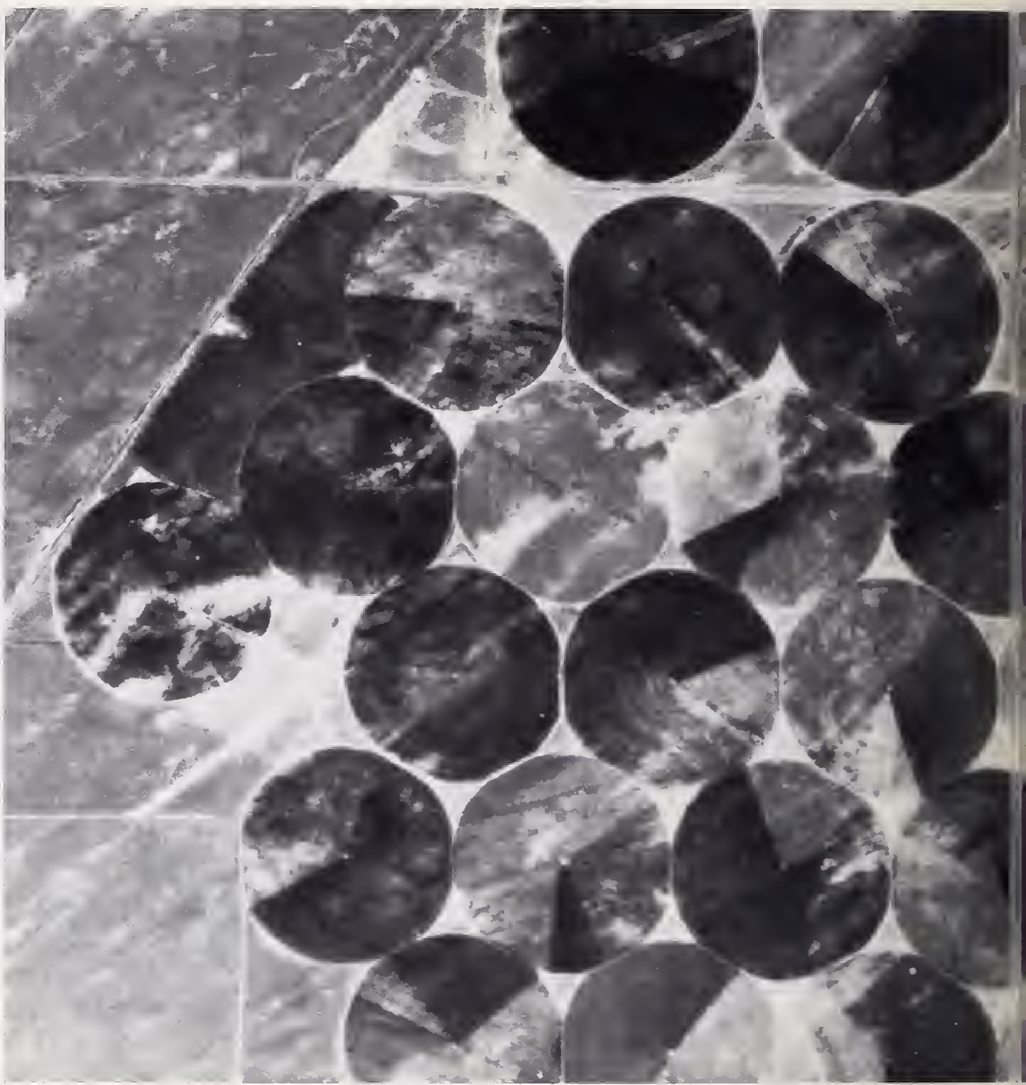
The first method dealt with changes in surface air temperature from variations in radiation that were caused by variations in airborne dust over Phoenix. The second method used 30 years of data on temperature changes caused by variations in water vapor over the city. The third method involved a comparison of the annual solar radiation and air temperature cycles of 105 U.S. weather stations. A fourth method, more exotic and scholarly than the other three, involved the entire globe. It also produced the 1/4°C figure.

"I can only conclude that the results of most current numerical models of the atmosphere which treat the CO_2-climate problem are grossly in error," Idso says. "If one is to look seriously at the problem, it is imperative that it be looked at through the 'living laboratory' of the world itself for validation of the mathematical models."

His conclusion? The CO_2 question is absolutely a nonproblem.

Sherwood B. Idso is located at the U.S. Water Conservation Laboratory, 4331 E. Broadway Road, Phoenix, AZ 85040.—(By Paul Dean, Oakland, Calif.) ■

Irrigation in the West



Above: Agricultural engineer Harold Duke, Ft. Collins, Colo., kneels at a pneumatic irrigation valve. This low-cost new timing system developed by Duke and others could be used on 8 million irrigated acres in the West. (0981X1109-27a)

Below: Allen R. Dedrick stands beside an irrigation jack-gate. The gate, developed at the U.S. Water Conservation Laboratory, Phoenix, Ariz., is controlled by a central timeclock for precise water applications. (0377X342-11)

Right: Logs in woodpile? No, a high-altitude view of center-pivot sprinkler systems on the western plains. Each circle contains about 125 acres. (WN-90,469)

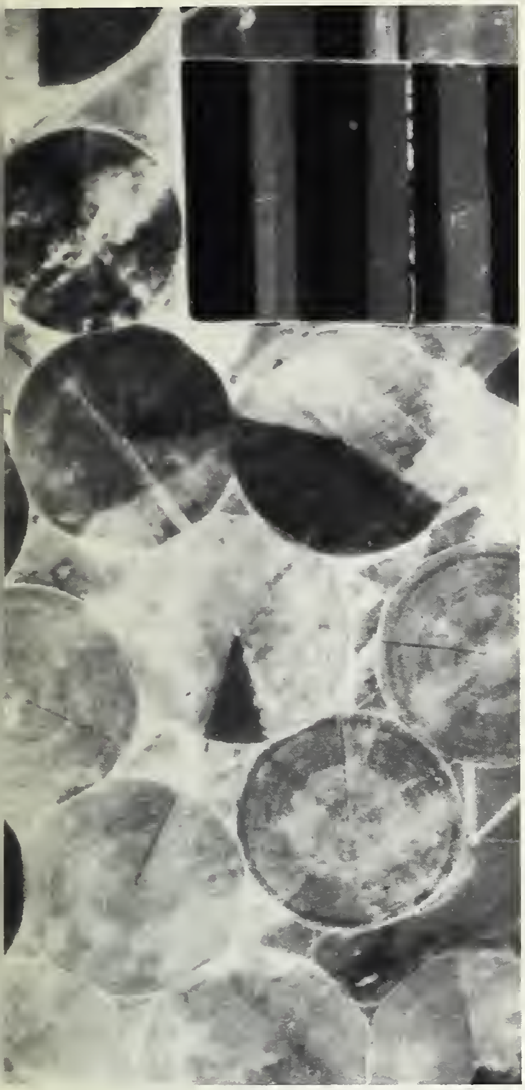
Far Right: James D. Rhoades, soil scientist, U.S. Salinity Laboratory, Riverside, Calif., sifts salt-laden earth in a Kern County cotton field. Such fields can sometimes be reclaimed through high-volume irrigation. (1178X1476-35a)

Irrigation is one of the oldest known agricultural technologies. It enabled civilizations to build permanent homes in semiarid and arid lands. Around 4000 B.C., residents of Mesopotamia (an ancient country in Asia between the Tigris and Euphrates Rivers) developed ways to keep their irrigation canals free of sediment. Shallow wells and flooding from the Indus River of present day Tibet, Kashmir, and Pakistan were used for crop production about 2500 B.C. Records indicate that irrigation was used along the Yellow River of China in 2627 B.C. and in Peru about 1000 B.C.

Many of these civilizations ultimately collapsed because the land became too salty for crop production.

In the United States, evidence suggests that the Hohokam Indians of the Salt River Valley of Arizona built extensive irrigation canals around 100 B.C. These ancient systems at one time irrigated more than 1/4 million acres, which produced crops to support a population estimated to have been 1/2 million. Spanish settlers and missionaries established small irrigation projects in the Southwest during the 16th and 17th centuries.

It wasn't until the mid-1800's that modern irrigation developed along streams in the western United States. Farmers and ranchers developed most of these projects. The Desert Land Act of 1877 and the Carey Act of 1894 were designed to stimulate private and state development. Passage of the Reclamation Act of 1902 brought additional Federal involvement.



Early irrigation in this country relied on gravity for water transport. Part of a river upstream from the irrigated area was diverted into canals that transported water to the fields. Utilization of electricity, internal combustion engines, and pumps permitted irrigation of areas at elevations above bodies of surface or ground water.

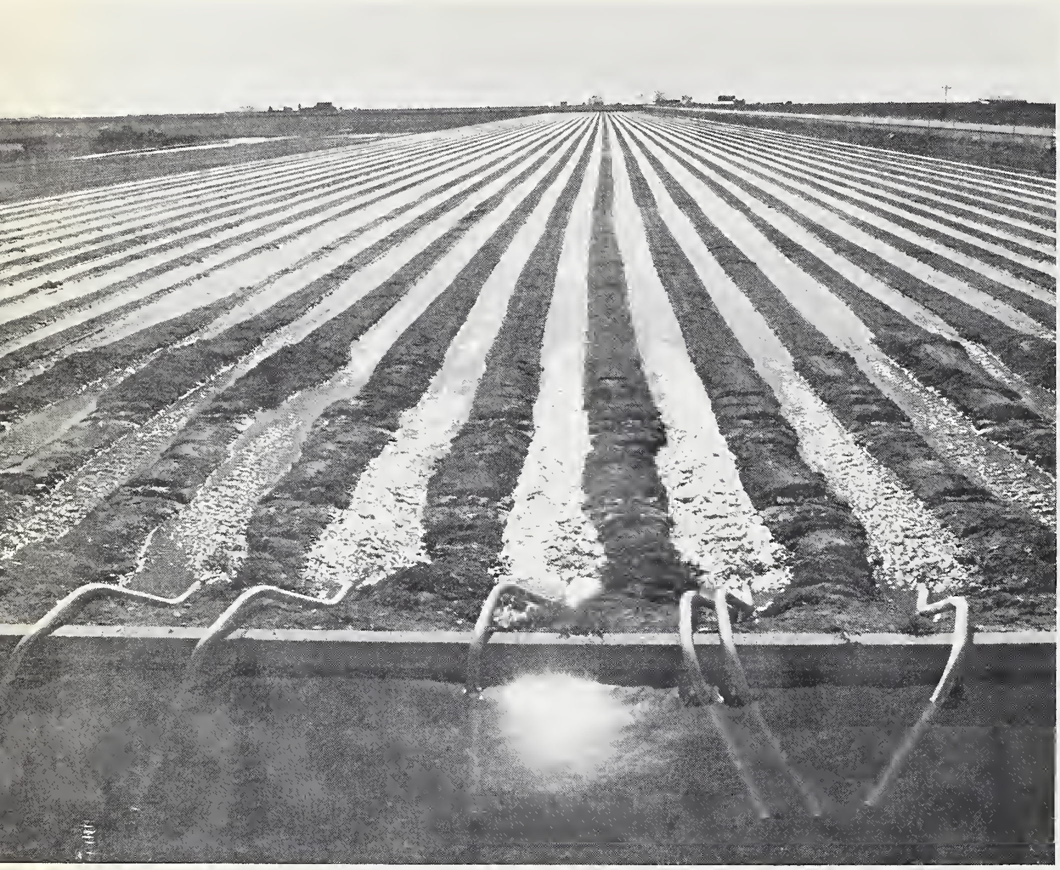
The center pivot sprinkler, patented in 1952, enabled farmers and ranchers to commercially irrigate medium- to coarse-textured soils and rolling agricultural lands unsuited for surface irrigation. Center pivots spray water from a lateral pipeline that swings in a circle, often 1/4- to 1/2-mile in radius, one end affixed to a water source. Center pivots have been improved over the years; some spray into field corners even though the sprinkler still moves in a circle. Other mechanical sprinklers move in straight lines, dispensing water as they move from one end of a field to the other.

Trickle irrigation is gaining widespread acceptance for some crops. Here, small-diameter plastic tubing delivers water to or near each plant. Small amounts of water trickle out and infiltrate root zones of individual plants. The tubing can be laid on the soil surface, shallowly buried, or supported above the surface on trellises.

According to the *Irrigation Journal's* 1981 survey, more than 61 million acres of land were irrigated in the United States last year, up from the 53 million acres the survey indicated in 1974. Of the 1981 total, 85 percent is in 17 western states from North Dakota to Texas and west.

Future development of irrigated land will be more difficult. New projects will be more expensive because of escalating construction costs and because most of the "easy" projects have already been developed. And there is more concern about the effect these projects have on our natural resources.

Increased salt concentrations in irrigation water return flows is one of the major problems facing the industry. Generally about one-half to three-fourths of applied irrigation water is evaporated or transpired by crops. Much of the remainder, which contains the dissolved salts, percolates below the soil root zone directly to the water table or moves laterally through subsurface drains into other water bodies.



This furrow irrigation system is gravity fed by siphon tubes from a concrete-lined ditch. Such systems have been used for several decades. (Photo, Grant Heilman)

If salt deposits are present in shallow geologic strata below the root zone, they may be dissolved and added to the concentration of the ground waters, which eventually flow to some receiving stream, deteriorating its quality.

Escalating energy costs, plus unavailability of additional energy at any cost, may limit development of irrigation where pumps are required for lifting or pressurizing water.

"As urban areas expand even more, competition between city dwellers and farmers and ranchers will increase for the finite amount of fresh water available. We view the problems facing the future of irrigation as a challenge," says Marvin Jensen, ARS National Program Staff-Water Management, Fort Collins, Colo.

ARS scientists are conducting research to improve western irrigation efficiency at several locations.

For example, at Fort Collins, scientists are devising ways to integrate computer scheduling with electrical load control to reduce energy consumption in sprinkler systems and to balance electrical load during peak hours. Fifteen center pivots are being equipped with radio controls to evaluate this technique. The scientists also are developing advanced automatic equipment for controlling surface irrigation, including automation of water turnout onto the field, volumetric irrigation control, and electronic devices to measure flow.

At Kimberly, Idaho, projects involving all major irrigation methods are being conducted to improve soil and water management techniques and to bring soil and water pollution from irrigation under control. Computerized irrigation scheduling, sediment collection ponds, buried irrigation return pipes, and the new, gravity-powered, uniform distribution "Cablegation" system (see *Agricultural Research*, June 1981), designed specifically for farmers who need an alternative to expensive sprinkler systems, are but a few of the studies.

At Fresno, Calif., scientists are developing techniques to manage rising perched water tables, to dispose of agricultural waste waters, and to maintain a workable salt balance within individual irrigation districts and hydrologic units as well as for the whole watershed.

At Phoenix, Ariz., scientists at the U.S. Water Conservation Laboratory are testing various designs of drip irrigation emitters and developing water treatments to reduce emitter plugging. Their research also includes developing: automatic irrigation systems capable of applying correct amounts of water to several fields in sequence; techniques for high-rate flooding of basins leveled with laser-controlled earth-moving equipment to increase uniformity of irrigation; high-flow-rate irrigation structures that minimize field erosion; improved techniques for conventional graded border and furrow irrigation systems; techniques for using crop temperatures (measured with infrared thermometers) to determine when to irrigate; simple, low-cost devices to measure water flow in irrigation ditches, and treatment technology for using municipal waste water for irrigation.

At Riverside, Calif., scientists at the U.S. Salinity Laboratory are seeking ways to handle increasing salt concentrations in irrigation water. This includes finding what concentration various crops can tolerate, recycling drainage water, and mixing salt water with higher quality irrigation water.

ARS scientists also conduct irrigation research at Prosser, Wash.; Brawley, Calif.; Sidney, Mont.; Grand Junction and Akron, Colo.; and Pendleton, Oreg.

Marvin Jensen is located at Drake Executive Plaza, 2625 Redwing Rd., Fort Collins, CO 80526.—(By Dennis Senft, Oakland, Calif.) ■

Controlling Water Pollution from Small Feedlots

Many cattle on small farms in the eastern United States are being fed on small paved lots, and runoff from these lots often carries pollutants into nearby streams. Although we do not know exactly how serious the problem is, federal tax funds and farmers' dollars are being spent to reduce runoff from these small feeding operations.

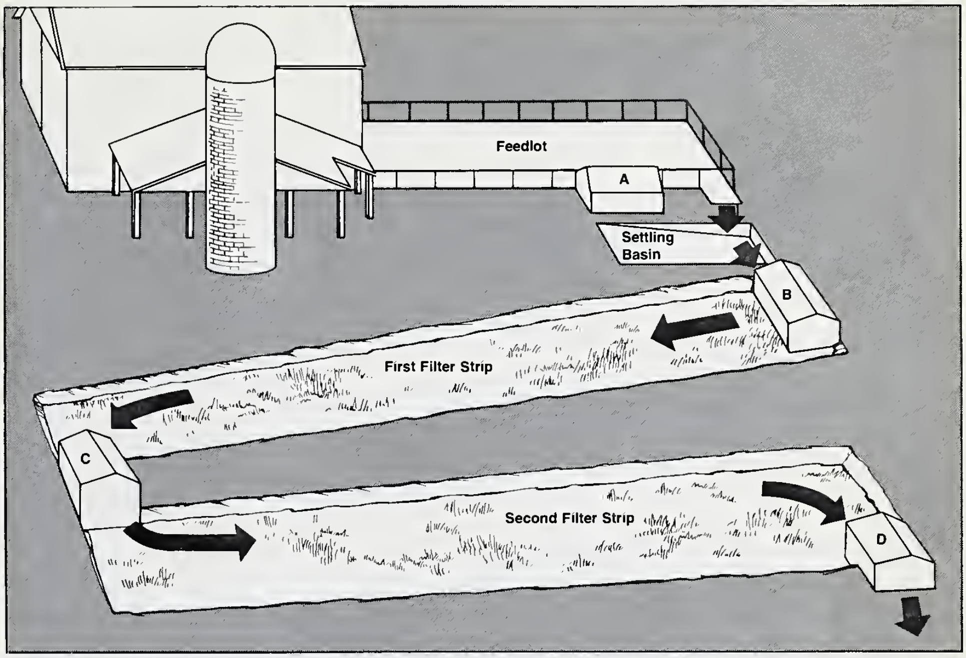
William M. Edwards, soil scientist at the North Appalachian Experimental Watershed, designed a 3-year study to evaluate the runoff quality from a typical small paved feedlot and from an unpaved feedlot. He also developed and tested facilities to control pollutants in the runoff.

Each October for 3 years a 2,600-square-foot feedlot was stocked with 56 steers that were fed corn silage until March. Then the ration was gradually shifted to shelled corn for the last 3 months of growth. The animals were removed in small groups as they reached market weight.

A 400-square-foot settling basin caught all runoff from the paved lot. Overflow from the basin then moved in sequence through two filter strips of fescue sod, each 100 feet long by 15 feet wide.

Runoff material was evaluated at four points: as it came off the feedlot, as it overflowed the settling basin, and as it left each of the filter strips.

Edwards, working with another ARS soil scientist, Lloyd B. Owens, and agricultural engineer Richard K. White of Ohio State University, analyzed the water for chemical oxygen demand, biological oxygen demand, total solids, total and soluble nitrogen, phosphorus, and potassium.



Feedlot with runoff management system. Runoff measuring and sampling stations are at (A) the feedlot, (B) the settling basin, (C) the first filter strip, and (D) the second filter strip. (PN-6852)

"The settling basin was very effective in reducing solids and nonsoluble materials in the runoff," Edwards said. "The filter strips were more effective in removing the soluble ammonium nitrogen, phosphorus, and potassium. Reduction of these chemicals was as effective in the second filter strip as in the first, indicating the value of the additional filtering area under these test conditions."

Concentrations of all materials being measured were higher in the latter part of the feeding cycle when the ration was higher in shelled corn than in corn silage. Animals fed corn silage produce a coarser textured manure, which is more easily retained in the settling basin after each runoff event.

Runoff from the paved lot equalled about two-thirds of total precipitation while runoff from the unpaved lot equalled about one-third.

"In many cases money is spent to improve feedlot runoff quality with inadequate knowledge of how bad the problem is and how much good the proposed treatment will do. Applying the results of this study will improve the efficiency of money invested in control of feedlot runoff," Edwards said.

In continuing research, Edwards is testing reed canarygrass in the filter strips and is also evaluating the effects of tile drainage systems beneath them.

William Edwards is located at the North Appalachian Experimental Watershed, P.O. Box 478, Coshocton, OH 43812.—(By Ray Pierce, Peoria, Ill.) ■

New Poultry-Handling Cage

Above: Lift truck stacks empty cages two high onto a transport truck. The enclosed cab protects the operator from environmental pollution. (0382X146-6)

Below: Operator checks that each cage is empty and then manually closes the doors. A cage ready for unloading rests on the tilting platform to the right. (0382X148-22a)

A revolutionary new system developed by ARS engineers for handling live broilers from the farm to the processing plant is paying off in dollars—and sense—for the poultry industry.

From a 1980 prototype installed at cooperating Marell Poultry, Inc., Murrayville, Ga., the system has evolved to successful installations in processing plants in Georgia, Texas, Arkansas, Mississippi, Florida, Virginia, and Maryland, with others yet to come.

Agricultural engineer A. Don Shackelford, former engineering technician John H. Holladay, and former agricultural engineer William K. Whitehead conceived and developed the innovative system at the Richard B. Russell Agricultural Research Center, Athens, Ga. According to Shackelford, industry-wide adoption could reduce the costs of marketing poultry by approximately $48 million annually.

One major key to the success of the new system is the use of a large-capacity metal cage, which replaces about 30 standard poultry coops for transporting live chickens. With the new cage, chickens are transported more economically and more safely and humanely.

"Practical experience with industrial receiving dock handling of the cages proves that the system can handle and empty 30 cages per hour," says Shackelford. "This represents a production rate of about 10,000 broilers per hour. For example, 30 of the new cages can handle a production rate of 9,600 broilers per hour compared with 800 coops per hour for a comparable number of broilers."

A typical poultry transport truck that normally hauls 520 standard coops is now loaded with 20 cages, which can transport 1,000 broilers more than normally transported in coops.

The chickens have adequate space in the large new cages, and in actual practice are loaded in accordance with the season. In warm summer months fewer birds are transported per unit of space than in winter.

The three main developments of the coopless transport system are large transport cages, hydraulic boom clamps mounted on powered lift trucks, and cage unloaders and conveyors for receiving dock handling of the containers and broilers.

The cage, 48 inches wide, 96 inches long, and 52 inches high, is divided into 10 compartments 5 tiers high, with 2 compartments per tier. The frame is constructed of rectangular and square steel tubing. The sides and top are expanded metal spotwelded to the frame. Floors are galvanized metal.

Hinged compartment doors are designed to stay safely closed when the cage is handled by the lift truck and during transportation.

The boom clamp telescopes horizontally and vertically for positioning over the cage, controlled by the lift operator

who regulates the rate of emptying broilers. The cycle time of the tilting platform for rotating the cage, emptying the broilers, and returning is about 10 seconds.

Hoppers mounted to the support frame of the unloader provide a smooth, slippery surface for sliding the broilers from the cage to the belt conveyors.

This is how the process looks to an observer:

The transport truck loaded with empty cages arrives at the poultry farm and the truck is positioned near the broiler house.

The lift truck operator positions the cage inside the house near the broilers, rotates it about 20° and lowers it onto a 20-inch-high portable stand in the center and under the door side of the cage. A six-person catching crew picks up the broilers, and after the cages are loaded one attendant secures the door and counts the broilers.

The broilers slide down the inclined floor toward the rear of the compartment and easily regain their balance. There is no "pile-up."

At the receiving dock of the processing plant, the loaded transport truck is driven onto the unloading apron near the receiving dock conveyor. When the lift truck puts the cage on the conveyor, the operator releases the clamp and returns to the truck for another cage.

The cages are conveyed onto the tilting platform of the unloader for automatic broiler removal. As the cage is tilted about 48° from horizontal, the birds gradually slide toward the side and their weight opens the spring-loaded cage door. The broilers then slide out slowly onto the hoppers and onto the belt conveyors without injury.

The top two layers of broilers are emptied onto the top belt and the lower three layers are deposited onto the bottom belt. The top belt travels in a direction counter to the bottom belt, maintaining a constant flow of broilers to the bottom belt and providing added broiler storage when the cage is emptied.

Inside the hanging area the workers remove the broilers from the conveyor and place them in the picking line—another advantage over manual removal from coops that contributes to the safety of the chickens.

"Broiler companies report a reduction of 10 to 20 workers," says Shackelford.

"There is a significant improvement in grade and higher yields. Maintenance costs of the cages are also lower compared with coop systems."

A. Don Shackelford is located at the Richard B. Russell Agricultural Research Center, P.O. Box 5677, Athens, GA 30613.—(By Peggy Goodin, New Orleans, La.) ■

Operator tilts platform holding poultry cage. The broilers slide slowly out onto a conveyor belt. (0382X148-6a)

Better Insecticide Sprayer Sprays Less

Applying insecticides with modern equipment—and only when and where needed—reduced the amount of chemicals applied to high-value row crops by about 50 percent.

T. L. Ladd, ARS research entomologist, used a sprayer turned on and off automatically by a photoelectric control. The intermittent sprayer was developed and tested by ARS agricultural engineer Donald L. Reichard.

It projects an infrared light beam across the plant row as the machine moves across the field. Plants interrupting the light beam automatically trigger the unit and get sprayed. When the light is not interrupted, no spray is applied.

Ladd and Reichard have been working with various intermittent sprayers and application systems for several years (see *Agricultural Research*, Nov. 1978, p. 16). For the first time they have used the photoelectrically controlled sprayer in conjunction with insect population counts. Ladd checked both spring- and summer-transplanted cabbages for signs of cabbage loopers and imported cabbage worms. When numbers reached a potentially damaging level, he applied an insecticide treatment.

The researchers, including Ohio Agricultural Research and Development Center entomologist Donald E. Simonent, are all stationed at the Center, Wooster, Ohio. They compared the amount of chemicals used by their system with a weekly insecticide application by a continuous spray system typically used in production of commercial fresh market cabbage.

"We used less than half as much insecticide on the summer planting with our system as we did with the weekly, continuous spray method," Ladd says. "When we used the intermittent sprayer weekly, regardless of the insect population, we still used 40 percent less insecticide.

"The chemical amounts used clearly demonstrate the advantage of basing applications on population counts or other evidence of insect activity. Even with the continuous sprayer, when applications were based on population counts, 26 percent less insecticide was used compared to the weekly spray schedule," Ladd says.

Insect infestations in cabbage transplanted in the spring were so small and late that both the continuous and the intermittent treatments based on population evaluation used 75 percent less insecticide than the weekly, continuous spray treatment. The intermittent treatment, applied weekly, used 21 percent less insecticide than the continuous sprayer.

"No significant differences existed in the numbers of insects or in the quantity or quality of cabbages produced under any of the spray systems," he says. "All treated plots of summer cabbage yielded at least 50 percent more than untreated plots. In fact, for the fresh market, nearly all the untreated cabbages were unmarketable."

The differences in the amount of insecticide used are largest while plants are small. After plants grow to fill in the entire row, the intermittent sprayer applies insecticide most of the time anyway, the same as the continuous sprayer, Ladd adds.

"It seems to me that photoelectrically-operated intermittent sprayers, used in conjunction with population counts, could well reduce the amounts of pesticide needed to control pests in a number of situations, particularly where small transplants or newly emerging seedlings are subject to early or massive attack by insect pests or plant disease organisms," Ladd says.

The amount of chemical that can be saved depends on the crop, planting date, spacing within the row, pests of the crop, time of appearance of the pests, rapidity of population buildup, and the speed of plant growth in the row, he adds.

T. L. Ladd is located at the Ohio Agricultural Research and Development Center, Wooster, OH 44691.—(By Ray Pierce, Peoria, Ill.) ■

Three spray nozzles are activated when a plant interrupts an infrared light beam. The photoelectric transmitter and receiver are mounted slightly in front of the nozzles. (0981X1067-5)

Research technician Charles R. Buriff tests the sprayer on young pepper plants. The insecticide is applied intermittently so that only the plants are sprayed (0981X1067-34a)

Fighting Food Poisoning

A microorganism that causes food poisoning, *Clostridium perfringens,* strikes many thousands of Americans annually, despite decades of research to control it. Probability for early detection and control of this bacterium got a boost recently with scientific discoveries at laboratories in California, Georgia, and Massachusetts.

C. perfringens food poisoning is caused by spores (dormant form of bacteria) that contaminate food. These heat-resistant spores survive cooking, and then germinate to form bacteria that may double every 10 minutes when food temperatures range between 95° and 120°F. If these spores are in cooked foods like turkey or roast beef, and are kept warm for 3 hours, a single spore can form more than 100,000 bacteria.

These bacteria, of which there are several types, can form spores in the small intestine, and during the process, produce an enterotoxin that causes the poisoning symptoms. Victims experience diarrhea, abdominal cramps, and sometimes nausea and headache. The symptoms usually occur within 6 to 22 hours after eating. Of the other two major causes of food poisoning, *Staphylococcus* generally causes symptoms sooner, and *Salmonella* generally later.

C. perfringens can also cause gas gangrene in humans and several serious diseases in livestock.

Discovery of a medium that supports growth and sporulation of *C. perfringens* by ARS microbiologist Lawrence E. Sacks, Western Regional Research Center, Berkeley, Calif., should accelerate research. Before this development, scientists had great difficulty growing enough spores for their studies.

"The growing medium was defined—meaning that the chemical nature of all ingredients is known. This allows biochemical analysis during spore growth and makes it possible to study the critical factors affecting spore and toxin formation," says Sacks, who worked with biological laboratory technician Precious A. Thompson (retired) on this development.

Three years ago Sacks and Thompson noticed that caffeine and theophylline, when added to the defined medium, greatly increased spore formation in several strains of *C. perfringens*. This was surprising because never before had a nonphysiological chemical increased spore formation in any type of bacteria.

Recently microbiologist Ronald G. Labbe, University of Massachusetts, Amherst, announced that in addition to greater spore formation, the growing medium also promotes high levels of toxin formation. With some strains of *C. perfringens,* he found that caffeine can greatly increase toxin and spore formation.

Sacks and Thompson went on to discover that papaverine, a smooth muscle relaxant used in human medicine, also effectively increases spore and toxin formation with some strains. They also tested several related chemicals and found them to be equally effective. This group of chemicals share certain physiological properties with caffeine and theophylline.

Additional research conducted by ARS microbiologists Stephen E. Craven and Leroy C. Blankenship of the Richard B. Russell Agricultural Research Center, Athens, Ga., shows that papaverine, caffeine, and related chemicals are effective and that their effectiveness varies with the strain being tested.

"These discoveries are important not only in expediting research that may lead to better detection, typing, and control of *C. perfringens* food poisoning, but may also provide valuable clues as to what exactly triggers sporulation genes to express themselves. Sporulation is a primitive form of differentiation, central to developmental biology and cancer studies. This research may also reveal more about possible effects of caffeine, which is found in coffee and tea, and theophylline, which is found in tea, on humans," says Sacks.

Lawrence E. Sacks is at the Western Regional Research Center, 800 Buchanan St., Berkeley, CA 94710. Stephen E. Craven and Leroy C. Blankenship are at the Richard B. Russell Agricultural Research Center, P.O. Box 5677, Athens, GA 30613.—(By Dennis Senft, Oakland, Calif.) ■

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Agrisearch Notes

Hessian Fly Attacks Spring Wheat. The Hessian fly, a newcomer to dryland wheat-producing areas of the Pacific Northwest, poses a potentially serious threat to spring wheat yields.

In a 2-year ARS study, spring wheat grown under reduced tillage management was highly susceptible to Hessian fly damage, especially if nitrogen fertilization was inadequate. Under this condition, yields were less than 30 percent of what could normally be expected. The flies, however, caused no observable damage to winter wheat yields.

ARS soil scientist Ronald W. Rickman and plant physiologist Betty Klepper, both at Pendleton, Oreg., conducted the study. The two researchers were among the first to report the insect's presence in eastern Oregon.

Primarily a pest of wheat, the Hessian fly has been in western Oregon and Washington since the late 1800's, but was not found east of the Cascade Mountains in Oregon until 1979 when some wheat yield losses caused by the insect were recorded.

In other parts of the United States, Hessian flies are controlled mainly by resistant wheat varieties, but these varieties aren't grown in the Northwest. Rickman and Klepper say that until resistant varieties for the Northwest are developed, nitrogen fertility will be the key to controlling the pest.

Adequate nitrogen fertility allows spring wheat to develop enough tillers to produce normal yields despite some tiller loss to the flies. Rotations that include a nonhost crop can also help.

Rickman and Klepper warn that reduced tillage, needed for erosion control, enhances Hessian fly survival and may require the use of an insecticide.

Rickman and Klepper are located at the Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97330.—(By Lynn Yarris, Oakland, Calif.)

Cotton Leaf Shape Affects Insects. Apparently the shape of cotton leaves has some influence on the "resistance" of the plant to newly emerged larvae and the mortality of eggs of the pink bollworm.

ARS plant geneticist F. Douglas Wilson recently summarized a 2-year study on the difference in damage to okra-leaf and normal-leaf cotton plants and found the okra-leaf plants had less damage.

Cotton leaves are separated into 5 shallowly divided parts, somewhat resembling a webbed hand. Okra-leaf plants are similarly shaped except that the 5 parts are more deeply divided.

During the 2-year study, Wilson and Boyd W. George, ARS entomologist, tagged cotton flowers and then hand-infested 10- to 13-day-old green bolls of okra-leaf and normal-leaf plants with pink bollworm eggs.

Both years, both the mean number of pink bollworm entrance holes per boll and the percentage of bolls having pink bollworm entrance holes were significantly lower in the okra-leaf than in the normal-leaf variety. The results, Wilson says, showed that eggs and first instar (newly hatched) larvae died more often on okra-leaf than on normal-leaf cotton.

Wilson says he believes the reason for the finding may be that okra-leaf cotton allows more sunlight to penetrate the lower reaches of the crop canopy, making a hotter, drier, and less favorable environment for young larvae and eggs.

F. Douglas Wilson and Boyd W. George are located at the Western Cotton Research Laboratory, 4207 E. Broadway Rd., Phoenix, AZ 85040.—(By Paul Dean, Oakland, Calif.)